Alternating Bundle Branch Block Together With Alternation of PR Intervals: Advanced Mobitz II Atrioventricular Block

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Certain electrocardiographic patterns are well recognized for their propensity to progress to more severe forms of atrioventricular (AV) block, thus requiring pacemaker implantation. This article presents an infrequently recognized and deceptively benign pattern of conduction abnormality with great potential for advancement to severe AV block and necessity for pacemaker therapy. The pattern consists of alternating bundle branch block (BBB) in unison with alternation of the PR interval so that the right BBB beats and left BBB beats appear to be wedded to their own but different PR intervals. It is hoped that the publication of these cases will contribute to the awareness of practicing cardiologists and electrophysiologists to the existence of this potentially serious form of AV conduction abnormality and hasten the implantation of pacemakers in patients who require them.

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Certain electrocardiographic patterns are well recognized for their propensity to progress to more severe forms of atrioventricular (AV) block, thus requiring pacemaker implantation. Included in this category are Mobitz II, bifascicular blocks (particularly right bundle branch block [RBBB] combined with inferior hemiblock), trifascicular blocks, and bifascicular blocks occurring in the course of an acute anterior myocardial infarction.

This article presents an infrequently recognized and deceptively benign pattern of conduction abnormality with great potential for advancement to severe AV block and necessity for pacemaker therapy. The pattern consists of alternating BBB in unison with alternation of the PR interval so that the RBBB beats and

left bundle branch block (LBBB) beats appear to be wedded to their own but different PR intervals.

In all, 16 cases with an adequate number of tracings of good quality and sufficient follow-up have been selected over 3 years of over-reading the computer interpretations of the electrocardiograms (ECGs) in a large teaching hospital. The ECGs displaying both RBBB and LBBB in the same or sequential tracings were identified and their respective clinical courses were analyzed on the basis of review of all the available ECGs and of the clinical events extracted from the patients' charts (Table 1).

Presentation

Of the 16 cases studied, 11 have been chosen for illustration. Figures 1 through 3 correspond to cases 1 through 3, which have been selected for detailed presentation. The other cases are depicted in composite pictures with a brief description of the salient features of each.

Case 1, Figure 1

Rhythm strips of VI are from a 65-year-old man with dilated cardiomyopathy suffering from dizziness and gait imbalance (Figure 1). An AV sequential pacemaker was implanted 2 weeks later when he returned with Mobitz II second-degree AV block.

The strips marked 1 to 5 are continuous recordings. Strip 6 is the same as strip 1. In strips 1, 2, and 3, RBBB with long PR intervals of 400 ms alternate with LBBB with shorter PR intervals of 280 ms. In strip 4, all beats show RBBB with long PR intervals and in strip 5, all beats are conducted with LBBB and short PR intervals. The LBBB beats in strip 1 may

Table 1
Synopsis of Cases Studied

Case	Age	Sex	Atrial Rhythm	Eventual AV Block Type	PR With RBBB	PR With LBBB	Pattern of Change From RBBB to LBBB and Vice Versa	Underlying Heart Disease
1	65	M	NSR	Mobitz II	400	280	Beat to beat or sequences of several like beats	Dilated CMP
2	64	M	NSR	Mobitz II	340	250	No specific pattern	CAD
3	71	F	NSR	Mobitz II	240	190	Sequences of several like beats	CAD
4	77	M	NSR	2:1 AV block	240-290	190	Abrupt switch from RBBB to LBBB and vice versa	CAD
5	86	M	NSR	Mobitz II	230	190	3:2 AV block with rate-related aberrancy	CAD
6	76	F	NSR	Mobitz II	240	180	Sequences of RBBB and LBBB with abrupt switch	CMP
7	85	M	NSR PACs	3rd degree	260	210	Switch from RBBB to LBBB after post-PAC pauses	HCVD
8	72	F	NSR	Mobitz II	280	210	Abrupt change	CAD
9	86	M	NSR	3rd degree	350	180-240	No identifiable pattern	CAD
10	73	M	NSR	Mobitz II and 2:1	230	180	Rate-related BBB	CAD
11	85	M	NSR	Mobitz II	240	180	RBBB and LBBB on different days	CAD
12	92	F	NSR	3rd degree	280	370	Sequences of 2 LBBB beats separated by 1 RBBB beat	CAD
13	89	M	NSR	Mobitz II	440	190	No identifiable pattern	CAD
14	85	M	NSR	Mobitz II	300	190	No identifiable pattern	HCVD
15	85	M	NSR	Mobitz II	340	200	PACs conducted either with RBBB-long PR or LBBB-short PR	Senile heart
16	81	M	NSR	Mobitz II	270	190	2:1 AV block with RBBB and 1:1 conduction with LBBB	

AV, atrioventricular; CAD, coronary artery disease; CMP, cardiomyopathy; F, female; HCVD, hypertensive cardiovascular disease; LBBB, left bundle branch block; M, male; NSR, normal sinus rhythm; PAC, premature atrial contraction; RBBB, right bundle branch block.

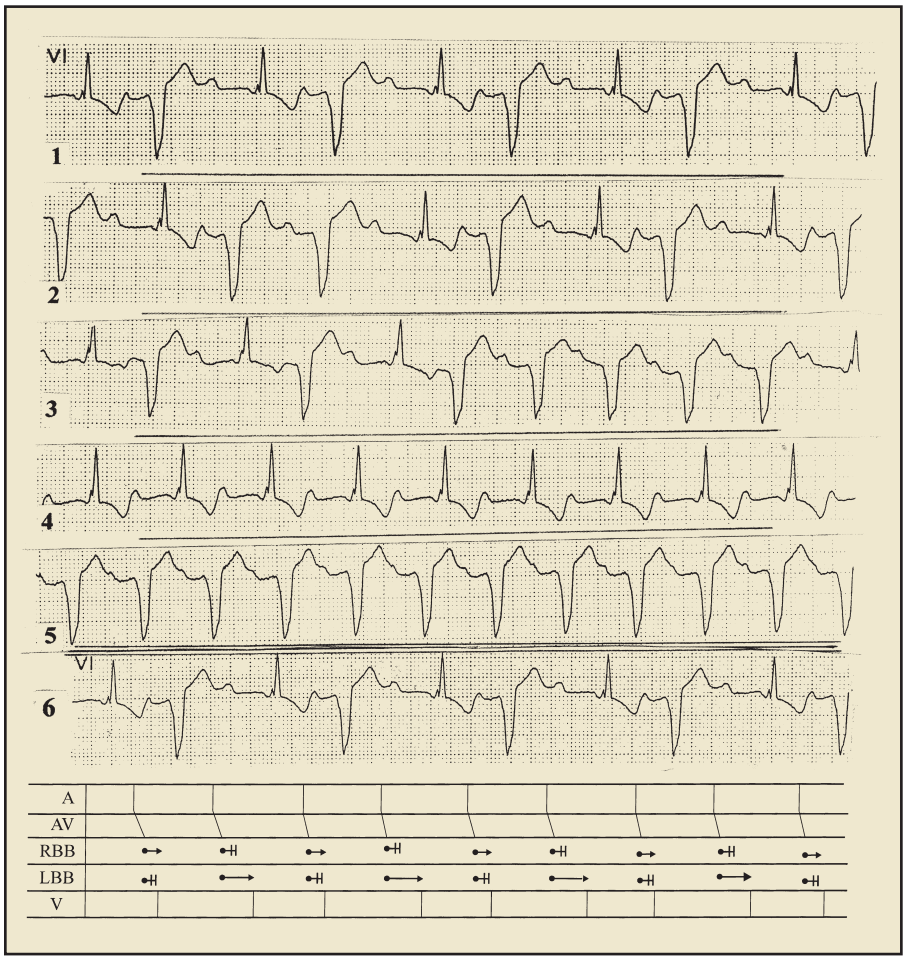

Figure 1. *Case 1: Six rhythm strips of VI showing variable mixtures of beats with RBBB-long PR and LBBB-short PR. The appearance of consecutive and uninterrupted beats with RBBB-long PR in strip 4 and LBBB-short PR in strip 5 documents the existence of 2 patterns of AV conduction resulting from shifting of AV conduction from the left bundle (strip 4) to the right bundle (strip 5). The diagram below strip 6 serves to demonstrate the pattern of conduction through the 2 bundle branches. Both bundles conduct in a 2:1 pattern. However, conduction time through the left bundle is long (400 ms) and through the right bundle is short (280 ms). To be noted in this and all other cases is that beats with RBBB and LBBB are always conducted with fixed PR intervals indicating unchanging conduction time through the conducting bundle, thus conforming to the pattern of Mobitz II. A, atrium; AV, atrioventricular; LBB, left bundle branch; RBB, right bundle branch; V, ventricle.*

have the appearance of premature ventricular beats. However, identical beats with the same PR intervals in strip 5 are clearly conducted and cannot be ventricular beats.

Strip 6 is used to analyze the function of each bundle. It may be noted in the diagram that each bundle conducts in a 2:1 pattern with its own conduction time. The left bundle conduction time is persistently longer than that of the right bundle.

Case 2, Figure 2

This 12-lead ECG with simultaneous rhythm strip of I, aVF, and VI was recorded in a 64-year-old man (Figure 2). It shows RBBB-long PR intervals (beats 2, 3, 7, 8, and 10) and LBBB-short PR intervals (beats 1, 4, 5, and 9), separated by long *R*-R cycles brought about by blocked P waves. Beat 6 is a premature ventricular complex. The diagram below the tracing helps to demonstrate the function of each bundle. The PR interval of beats 1, 5, and 9 after the long cycles are equal to the PR intervals of beat 4, which occurs after a short cycle, thus demonstrating lack of relationship between AV conduction time and the preceding cycle length. This behavior characterizes the AV block as Mobitz II. Again, it should be noted that conduction time through the LBB is persistently longer than through the right bundle. Nonconducted P waves occur when both bundles fail simultaneously.

Case 3, Figure 3

In this 71-year-old woman, an abrupt and unpredictable shift from RBBB with long PR to LBBB with short PR is depicted in the 3-lead rhythm strip (Figure 3, A). In strip B of lead VI, the reverse occurs, whereas in strip C only 1 beat with RBBB-long PR is present. Strip D of aVF was taken 2 weeks later after the patient required pacing for symptomatic near-complete AV block. It is noted that the change from RBBB to LBBB is not associated with any change of QRS axis, thus suggesting a lack of participation of the fascicles of the left bundle.

Figure 4, Cases 4, 5, and 6

Case 4. Case 4 shows LBBB-short PR complexes (1-5) changing abruptly to RBBB-long PR (6-9) in Strip A, and 2:1 AV block in Strip B, taken a few days before implantation of a pacemaker (Figure 4).

Case 5. Case 5 is presented in 3 strips of VI marked A, B, and C. In A, RBBB-long PR beats are followed by blocked P waves producing long cycles, following which the complexes show short PR interval and rate-related normalization of the QRS.

In B, Mobitz II AV block with narrow QRS is interrupted by 3 RBBB-long

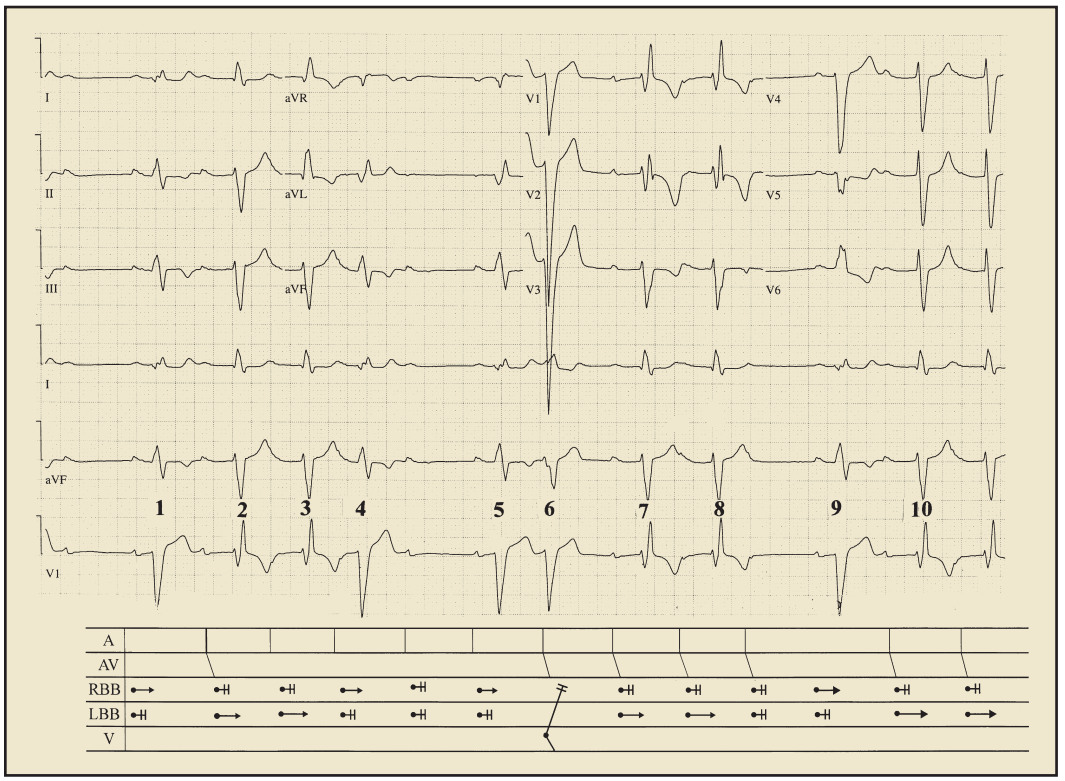

Figure 2. *Case 2: 12-lead electrocardiogram with simultaneous rhythm strips of I, aVF, and VI recorded in a 64-year-old man. RBBB-long PR beats coexisted with LBBB-short PR beats, indicating intermittent switching of AV conduction from the fast-conducting RBB (beats 1, 4, 5, and 9) to the slow-conducting LBB (beats 2, 3, 7, 8, and 10). Beat 6 is a premature ventricular beat. The diagram below the tracing analyzes the pattern of conduction in the 2 bundles. Failure of conductions through both bundles results in nonconducted P waves. A, atrium; AV, atrioventricular; LBB, left bundle branch; RBB, right bundle branch; V, ventricle.*

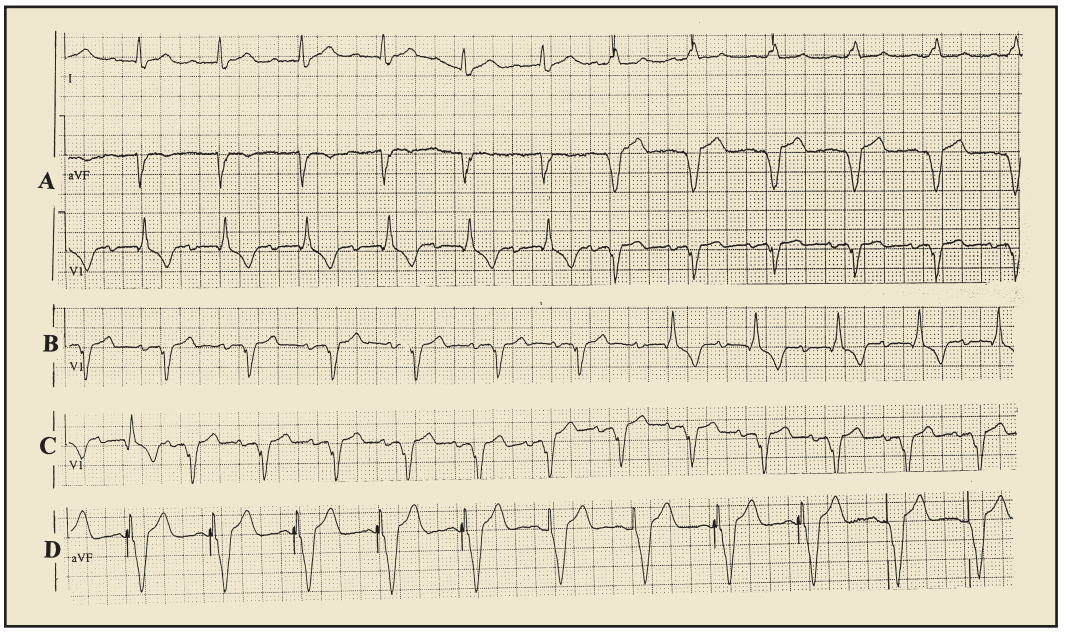

Figure 3. *Case 3: Abrupt shift from RBBB-long PR to LBBB-short PR occurred in a 71-year-old woman complaining of dizziness (rhythm strip A); the reverse happened in B. In C, only 1 RBBB-long PR interval was noted, whereas in D the need for pacemaker implantation is documented.*

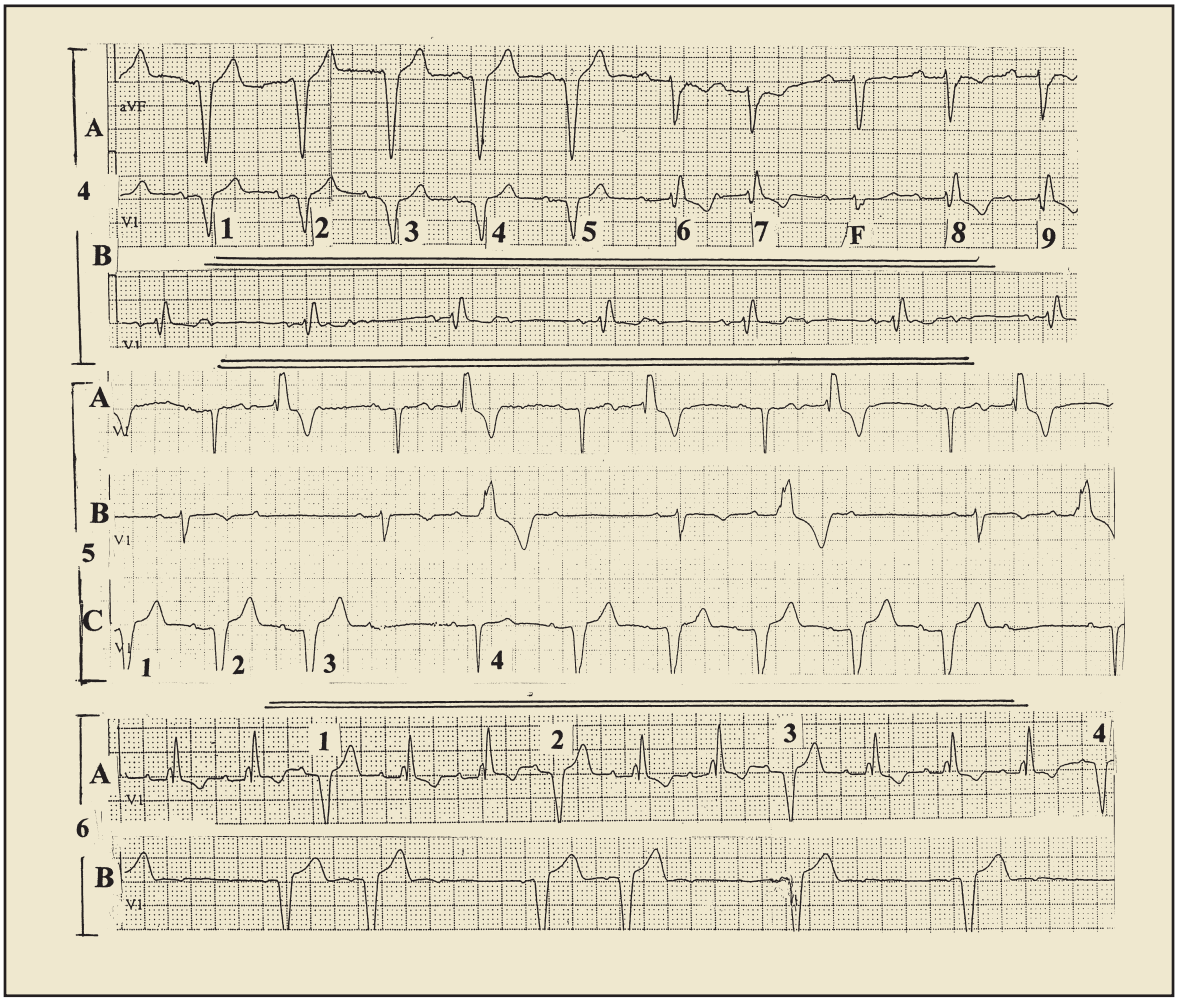

Figure 4. *Cases 4, 5, and 6: In case 4, LBBB-short PR unpredictably changes to RBBB-long PR (4A); later, 2:1 AV block develops and leads to pacemaker implantation. Case 5 displays several variations of the theme. In A, RBBB-long PR beats and short PR normal QRS alternate. Following each RBBB beat, a P wave fails to conduct, suggesting block in both bundles. Strip 5B demonstrates a mechanism similar to 5A. In 5C, only LBBB-short PR beats coexist with short PR normal QRS, again with occasional nonconducted P waves caused by failure of conduction through both bundles. Beat 4 is conducted normally because of the long preceding cycle. In case 6, RBBB-long PR beats and LBBB-short PR intervals appear intermittently (6A). In 6B, all beats display LBBB with a typical Mobitz II pattern of AV block.*

PR beats, and in C, beats 1, 2, and 3 display LBBB-short PR. Beat 4, occurring after a blocked P wave, again demonstrates rate-related normalized QRS following which the conduction pattern returns to 1:1 with LBBB-short PR.

Case 6. Case 6 is presented in 2 strips. Strip A displays alternation between RBBB-long PR and LBBB-short PR intervals (beats 1, 2, 3, and 4). Several days later, LBBB-short PR beats are seen with Mobitz II AV conduction pattern.

Figure 5, Cases 7, 8, and 9

Case 7. Four strips of VI show 4 different phenomena (Figure 5). In strip A, RBBB-long PR complexes 1 and 2 are followed by a pause brought about by a blocked premature atrial complex or an echo P wave marked by the downward arrow. Following the pause, both AV and IV conduction patterns normalize. The next few beats are again RBBB-long PR until another atrial premature marked by the arrow occurs and the phenomenon described earlier is repeated. In strip B, all beats are RBBB-long PR, and in strip C, all beats display LBBB-short PR. Strip D was taken 2 months later after implantation of an AV sequential pacemaker.

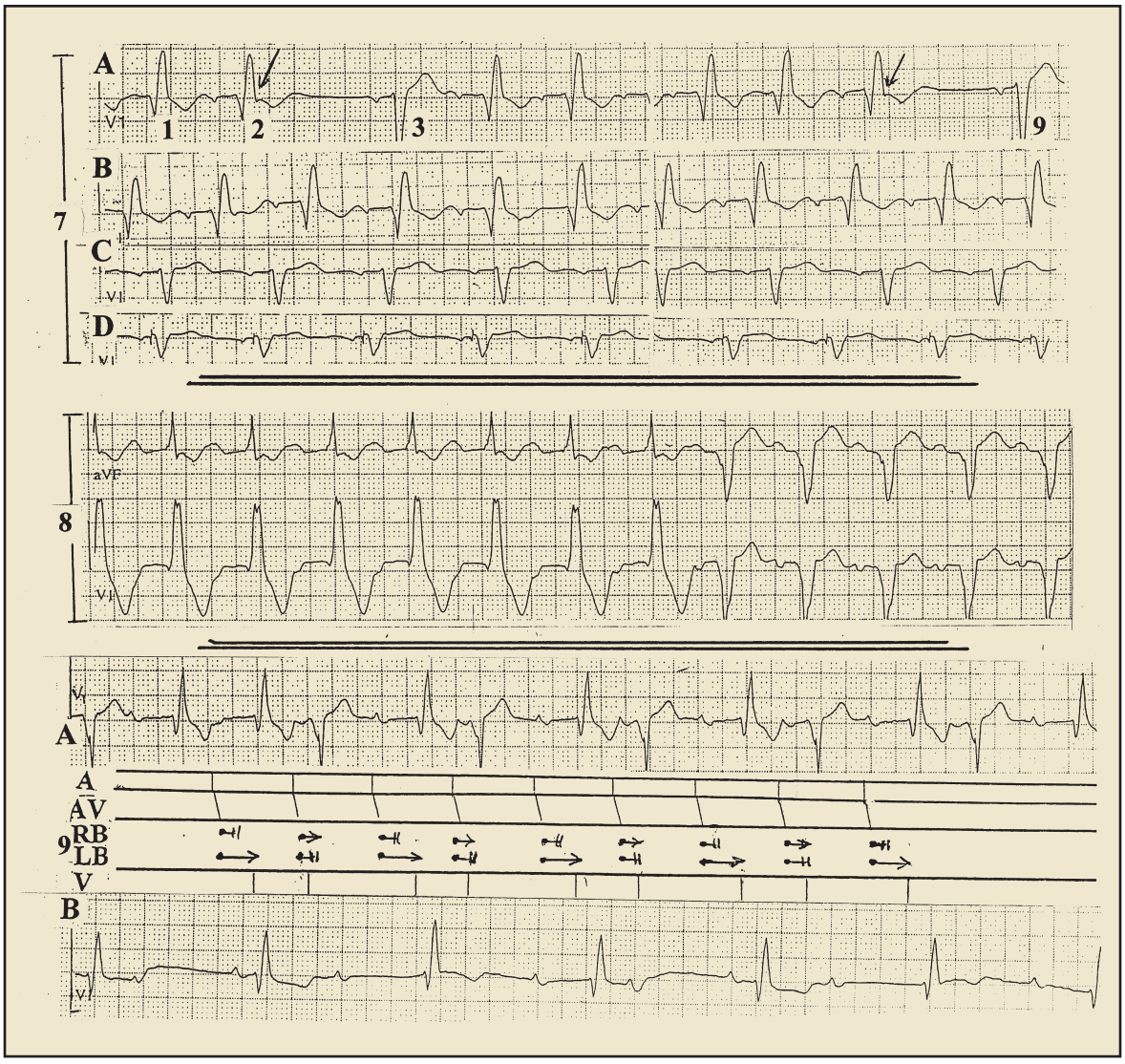

Figure 5. *Cases 7, 8, and 9: Case 7, strip A shows several beats with RBBB-long PR interrupted by nonconducted atrial prematures (arrows). Following the post-PAC pause, conduction through the right bundle recovers and a narrow QRS results. Strip 7B contains only RBBB-long PR beats and Strip 7C contains only LBBB-short PR beats. Soon after recording strip 7C, the patient required pacemaker implantation (7D). Case 8 demonstrates the abrupt change from RBBB-long PR intervals to LBBB-short PR pattern. Strip 9A shows alternating RBBB-long PR with LBBB-short PR intervals with progression to complete AV block shown in 9B. The diagram under 9A serves to display conduction through the 2 bundles. Note that each bundle conducts in a 2:1 manner, but with alternation. A, atrium; AV, atrioventricular; LBB, left bundle branch; RBB, right bundle branch; V, ventricle.*

Case 8. Rhythm strip of aVF and VI in a 72-year-old woman with coronary artery disease. The first 8 beats display 1° AV block with PR intervals of 250 ms and RBBB morphology. Then, abruptly, the PR intervals shorten to 210 ms and simultaneously the QRS morphology switches to LBBB. Electrophysiologically, during the fist 8 beats AV conduction proceeds through the left bundle with the long conduction time of 280 ms, while during the last 5 beats, AV conduction shifts to the right bundle, which conducts a shorter time of 210 ms. Both bundle branches conduct slowly but with different velocities.

Case 9. In strip A, RBBB-long PR and LBBB-short PR are interspersed in a predominantly alternating pattern, whereas in strip B, complete AV block supervenes and leads to the necessity of pacemaker implantation.

Figure 6, Cases 10 and 11

Case 10. Case 10 was observed at another institution. In this 73-year-old man, 3-lead rhythm strip (A) and 2 strips of VI (B and C) are depicted.

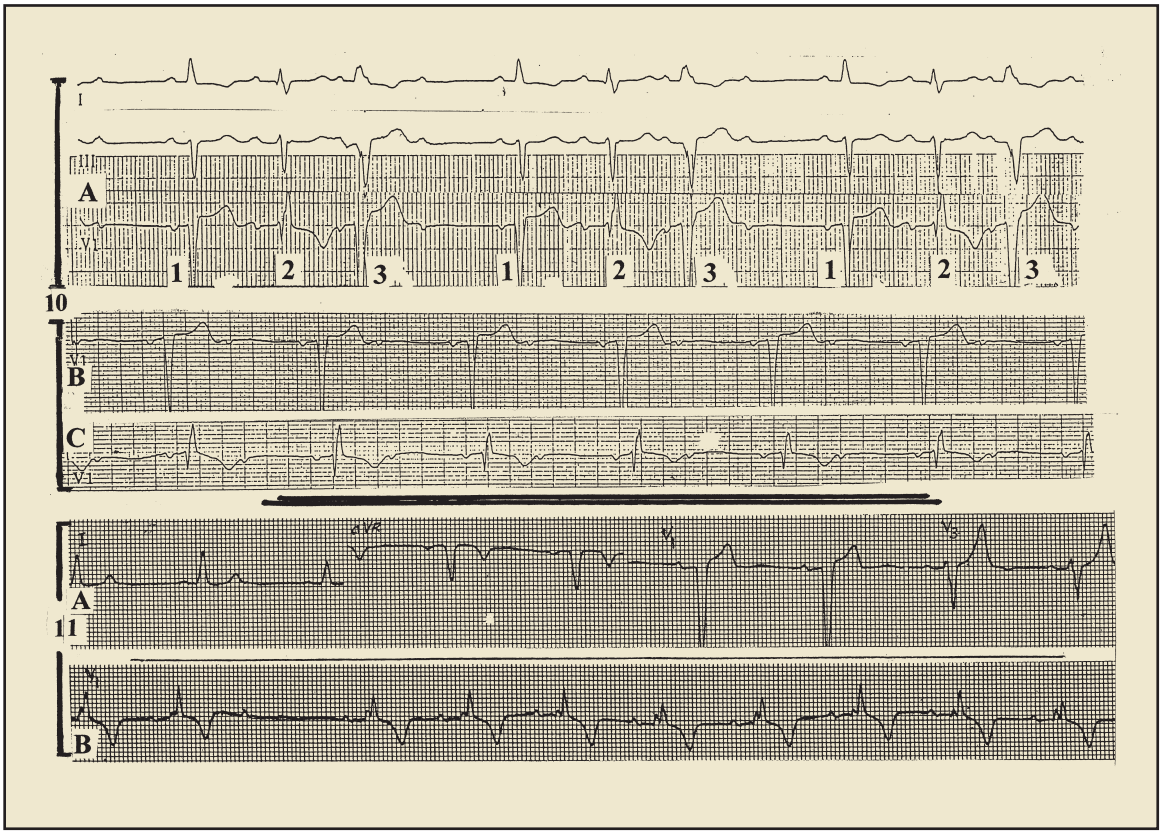

Figure 6. *Cases 10 and 11: In strip 10A, groups of 3 beats separated by blocked waves are present (beats 1, 2, and 3). Beat 1 is narrow thanks to the long preceding cycle. Beat 2 shows RBBB-long PR and 3 LBBB-short PR intervals. Strip 10B depicts 2:1 AV block with LBBB-short PR pattern, while strip 10C demonstrates 2:1 AV block with RBBB-long PR beats. Case 11 is another example of LBBB-short PR intervals (A) that change to RBBB-long PR intervals (B).*

The 3-lead rhythm strip shows groups of 3 beats separated by blocked P waves (Figure 6). Each 3-beat group consists of 1 rate-related narrow QRS-short PR, followed by 1 RBBB-long PR and then 1 LBBB-short PR beat. The VI strip B displays 2:1 AV block with LBBB-short PR and strip C shows a switch to RBBB-long PR with persisting 2:1 AV block.

Case 11. The ECG taken from an 85-year-old man with dizziness shows segments of a 12-lead ECG in strip A, and a rhythm strip of VI taken 1 week later (strip B). In strip A, LBBB-short PR is present whereas in strip B, RBBB-long PR with 1 blocked P wave corresponding to Mobitz II is noted. This patient required a pacemaker 3 months later.

Discussion

In addition to the well-recognized pattern of Mobitz II AV block as a precursor to more advanced conduction impairment requiring pacemaker implantation, this article describes a rarely appreciated pattern with a very high risk of progression to more severe forms of AV block.

The characteristic ECG pattern consists of alternating RBBB and LBBB together with alternation of the PR intervals, signifying impaired conduction of different magnitudes in the 2 bundles. The PR intervals tend to be nearly fixed for both RBBB and LBBB beats. It is of special interest but not well understood that in all but 1 of the 16 cases, PR intervals of RBBB beats were considerably longer than those of LBBB beats, indicating that in cases of bilateral BBB, conduction through the left bundle is slower than through the right.

In a previous study of AV conduction impairments, the author demonstrated, using His bundle recordings, that the difference in the PR intervals of RBBB and LBBB beats was accounted for entirely by the difference in His-V intervals. The A-His intervals were the same for both types of beats[1] (Figure 7).

As noted in the description of the cases, alternation of BBB appears in a

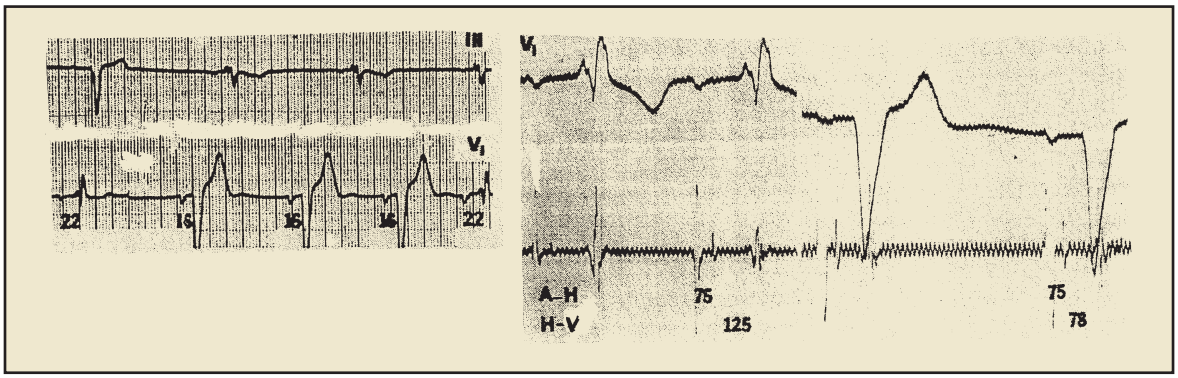

Figure 7. *In this case of alternating BBB and PR intervals, the PR intervals of RBBB beats are 220 ms and those of LBBB 160 ms. The difference in the PR intervals is accounted for entirely by the longer His-V intervals of 125 ms for RBBB beats in comparison with His-V intervals of 75 ms for LBBB beats. LBBB, left bundle branch block; RBBB, right bundle branch block.*

variety of sequences. Thus, a shift from RBBB with longer PR to LBBB with shorter PR occurred unpredictably and was the most common mode of presentation. Next was a sequence of several RBBB beats changing abruptly to a run of consecutive LBBB beats, and vice versa, or occasional nonconducted waves when both bundles failed simultaneously. The most common pattern was sinus rhythm with first-degree AV block where RBBB-long PR and LBBB-short PR occurred in alternating sequences.

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Nonconducted P waves were scattered throughout the tracings with no identifiable relation to the length of the preceding *R*-R cycles. When P waves where conducted, the length of the PR remained constant for each bundle with no regard to the preceding events, thus conforming to the main character of Mobitz II.

A review of the literature uncovered few references to the problem of BBBB and still fewer to the pattern of alternating BBB and PR intervals. Lepeschkin,[2] in an exhaustive review of the subject of bilateral BBB, mentioned all the numerous possible manifestations, including alternating RBBB and LBBB. Subsequently bilateral BBB and multifascicular block were briefly mentioned by several authors.[3-9] The following quotation is particularly germane to the cases presented here: "*Bilateral bundle branch block* also refers to those instances in which tracings from an individual patient show features diagnostic of RBBB in 1 tracing and of LBBB in another, or the 2 abnormalities may appear in alternation in the same tracing."[4]

Charles Fisch[5] was the first to describe the pattern under the name of *multifascicular block* and published a case demonstrating RBBB-long PR next to LBBB-short PR in the same tracing.

In 1998, in the textbook *Comprehensive Cardiovascular Medicine*,[6] it was suggested that documentation of trifascicular block requires the presence of alternating RBBB and LBBB or fixed RBBB with alternating left anterior-superior hemiblock (ASH) and posterior-inferior hemiblock (PIH). In another textbook, *Chou's Electrocardiography in Clinical Practice*, published in 2001,[7] a case is published with Morbitz II AV block, with longer PR intervals of 280 ms associated with RBBB and shorter PR intervals of 200 ms in company of LBBB. Even though the simultaneous alternation of BBB and PR intervals was not mentioned, the case resembles Case 2, presented here. Alternating BBB was cited as a class I indication for permanent pacing in 2004.[8]

In a 2006 monograph entitled, *The ECG in Emergency Decision Making*, Conover and Wellens stated "Those at highest risk for complete AV block development are patients with alternating bundle branch block."[9]

It is of interest that the example published there demonstrates a case of first-degree AV block in which LBBB-PR intervals of 250 ms abruptly change to RBBB-PR intervals of 280 ms, thus conforming to the pattern observed here.[9]

Conclusions

From the foregoing discussion, it should be apparent that the pattern of alternating BBB together with alternation of PR intervals has received only cursory attention. In the

present study the pattern was found in 16 cases in a period not exceeding 3 years. All the cases required pacemaker implantation.

It is hoped that publication of these cases will contribute to the awareness of practicing cardiologists and electrophysiologists to the existence of this potentially serious form of AV conduction abnormality and hasten the implantation of pacemakers in the manner similar to that in Mobitz II and more severe forms of AV block. It may be stated that the presence of alternating BBB in association with alternation of the PR intervals is a manifestation of disease in both bundles and thus an indication for pacemaker implantation even if no blocked P waves are found. ■

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Main Points

- Certain electrocardiographic patterns are well recognized for their propensity to progress to more severe forms of atrioventricular (AV) block, thus requiring pacemaker implantation.
- The pattern of alternating left bundle branch block and right bundle branch block together with alternation of the PR intervals, which signifies impaired conduction, is an infrequently recognized and deceptively benign pattern of conduction abnormality with great potential for advancement to severe AV block and necessity for pacemaker therapy.
- Practicing cardiologists and electrophysiologists should be aware of the existence of this potentially serious form of AV conduction abnormality and hasten the implantation of pacemakers, as they would in patients with other severe forms of AV block.